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Forward stroke volume is predictor of perioperative course in patients with mitral regurgitation undergoing mitral valve replacement

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Abstract

Background: *Decreased left ventricle ejection fraction (LVEF) is a predictor of poor late outcome in patients with mitral regurgitation (MR). The relationship between pre-operative forward stroke volume (SV) and right heart parameters and perioperative outcome in patients with MR has been little studied.*

Methods: *Forty patients with severe organic MR, unsuitable for mitral valve repair, who underwent mitral valve replacement (MVR) were included in the study (50% men, average age 61 ± 9 years). Exclusion criteria were: aortic valve disease, coronary artery disease, rethoracotomy, stroke, infection or significant perioperative bleeding. Pre-operative detailed echocardiographic examination was performed. The end-point was post-operative prolonged intensive care unit (ICU) stay of more than three days because of the need for inotropic support.*

Results: *Pre-operative NYHA class was 2.6 ± 0.4, mean right ventricular end-diastolic diameter (RVEDD) was 28.7 ± 4 mm, TAPSE was 20 ± 4 mm, mean right ventricular systolic pressure (RVSP) was 38 ± 13 mm Hg, left ventricular end-systolic diameter was 43.5 ± ± 11 mm, left ventricular end-diastolic diameter was 60 ± 11 mm, left ventricular end-diastolic volume (Simpson) was 155 ± 47 mL, LVEF was 55 ± 11%, mean regurgitation fraction was 58% and forward SV (measured by Doppler) was 35 ± ± 11 mL. All patients survived the operation. Mean ICU stay was 3.2 ± 2.9 days (range 1–10 days), mean TISS-28 was 623 ± 293 and mean NEMS 151 ± 85. By univariate analysis, ICU stay was significantly longer in patients in higher pre-operative NYHA ($p = 0.04$), lower LVEF ($p = 0.01$), lower forward SV ($p = 0.001$) higher RF ($p = 0.01$), pre-operative right ventricular dilatation ($p = 0.04$), higher RVSP ($p = 0.006$) and right ventricular dysfunction ($p = 0.04$). By multivariate analysis, forward SV ($p = 0.002$, $\beta = -0.45$) and RVEDD ($p = 0.02$, $\beta = 0.31$) were independent predictors for prolonged ICU stay.*

Conclusions: *Pre-operative forward stroke volume and right ventricle size are predictors of the perioperative hemodynamic status in patients with mitral regurgitation undergoing MVR.* (Cardiol J 2010; 17, 4: 386–389)

Key words: mitral regurgitation, stroke volume, right ventricle, mitral valve replacement, echocardiography, prognosis

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Introduction

In patients with severe mitral regurgitation (MR), increased left ventricular (LV) contractility triggered by adrenergic activation tends to maintain the forward stroke volume (SV) within normal limits in an initially compensated phase and patients can be asymptomatic over relatively long periods of time [1]. Chronic volume overload causes LV dysfunction, which is initially difficult to detect because of a 'false' increase of left ventricle ejection fraction (LVEF) due to low afterload. An LVEF decrease below the normal limit usually signifies severe LV dysfunction. Forward SV can be decreased in patients with 'normal' LVEF [2–5]. Preoperative symptoms, left ventricular dilatation and contractility and right ventricular systolic pressure (RVSP) are key elements for optimal patient management and powerful predictors of long-term post-operative outcome [6–8]. The evidence increasingly suggests that right ventricular size and function are also important determinants of late outcome [9–11]. For the prognosis of perioperative complications, the predictive significance of pre-operative SV and hemodynamic parameters of the right ventricle has been less studied.

The aim of this prospective study was to assess the relationship between pre-operative echocardiographic parameters and perioperative outcome.

Methods

The study group comprised 40 consecutive patients who underwent mitral valve replacement. Their baseline characteristics are detailed in Table 1.

The inclusion criteria were:

1. Severe organic MR unsuitable for mitral valve repair
2. Presence of symptoms or LV dysfunction in spite of optimized medical therapy.

The exclusion criteria were:

1. Moderate or severe aortic valve disease
2. Emergency operation
3. Chronic obstructive pulmonary disease
4. Severe tricuspid regurgitation
5. Concomitant coronary disease
6. Previous inferior wall myocardial infarction
7. Rethoracotomy, stroke, infection or significant perioperative bleeding.

All patients underwent pre-operative evaluation of clinical symptoms (NYHA class) and echocardiographic examination. The surgical technique was median sternotomy with cardiopulmonary bypass and mild hypothermia, aortic cross-clamping and intermittent cardioplegia. Mitral valve replacement (Saint-Jude Medical) with posterior chordal sparing was performed in all cases. Patients were observed until discharge from the intensive care unit (ICU). The analysed clinical parameters after surgery were: ICU length of stay, number of days of inotropic agent administration, and values of intensive care scores: TISS-28 (therapeutic intervention scoring system) and NEMS (nurses manpower use score).

The study end-point was defined as prolonged ICU stay (more than three days) due to hemodynamic compromise requiring inotropic support.

The study was approved by the local bioethical committee and all patients gave their informed consent.

Table 1. Baseline characteristics and relationship to the study end-point in univariate analyzis.

Characteristic	All patients (n = 40)	P
Age (years)	61 ± 9	> 0.1
Men (%)	50%	> 0.1
NYHA class	2.6 ± 0.4	0.04
RVEDD [mm]	28.7 ± 4	0.04
LVEDD [mm]	60 ± 11	> 0.1
LVESD [mm]	44.6 ± 12.6	> 0.1
LVEDV (Simpson) [mL]	160 ± 50	> 0.1
LVEF (%)	55.3 ± 11	0.01
RF (2D-Doppler) (%)	58 ± 15	0.01
SV (Doppler) [mL]	35 ± 11	0.0001
RVSP [mm Hg]	38 ± 14	0.006
TAPSE [mm]	20 ± 4	0.04
TISS-28 Score	623 ± 293	0.000001
NEMS Score	151 ± 85	0.000001
ICU stay (days)	3.2 ± 2.9	–

NYHA — New York Heart Association; RVEDD — right ventricular end-diastolic diameter; LVEDD — left ventricular end-diastolic diameter; LVESD — left ventricular end-systolic diameter; LVEF — left ventricular ejection fraction; RF — regurgitation fraction; SV — stroke volume; TAPSE — tricuspid annular plane systolic excursion; RVSP — right ventricular systolic pressure; TISS-28 — therapeutic intervention scoring system; NEMS — nurses manpower use score

Echocardiography

Echocardiographic measurements were performed according to the ASE/EAE recommendations [12, 13]. Right ventricular (RV) function was echocardiographically assessed by determining the tricuspid annular plane systolic excursion (TAPSE) [14]. Due to limitation of the PISA method in patients with organic mitral insufficiency [13], regurgitant volume and fraction were assessed using the two-dimensional-Doppler method (end-diastolic and

end-systolic volumes calculated with biplane Simpson method and forward stroke volume calculated at the level of left ventricular outflow tract) as previously described [13]. Echocardiographic images were recorded in DICOM format and stored for off-line analysis using a commercial PACS system (Medimatic Compacs).

Statistical analysis

Continuous variables were presented as mean ± ± standard deviation (SD) or median value (25 percentile, 75 percentile). Categorical variables were shown as absolute or relative frequencies. A two-tailed Pearson test or nonparametric Kendall test, as appropriate, was used for univariate analyzis. Multiple linear regression analyzis [15] with stepwise selection (probability of F to entry ≤ 0.05, probability of F to remove ≥ 0.1) was used to select independent predictors. $P < 0.05$ was considered statistically significant.

Results

The baseline characteristics are detailed in Table 1. All patients survived the operation. No patient had significant residual MR post-operatively. Mean ICU stay was 3.2 ± 2.9 days (range 1–10 days), mean TISS-28 score was 623 ± 293 and mean NEMS score was 151 ± 85. Eleven patients (27.5%) had an ICU stay of more than three days. By univariate analysis (Table 1), ICU stay duration was significantly longer in patients in higher pre-operative NYHA-class ($p = 0.04$), with lower LVEF ($p = 0.01$), lower forward SV ($p = 0.001$), higher RF ($p = 0.01$), pre-operative RV dilatation ($p = 0.04$), higher RVSP ($p = 0.006$) and RV dysfunction ($p = 0.04$). By multivariate analysis, forward SV ($p = 0.002$, $\beta = -0.45$) and RV end-diastolic diameter ($p = 0.02$, $\beta = 0.31$) were independent predictors for prolonged ICU stay.

By ROC analysis, stroke volume below 23 mL had 76% sensitivity and 100% specificity for predicting the end-point (area under the curve 0.76, confidence interval 0.61–0.91), while RV enlargement above 35 mm had 81% sensitivity and 91% specificity for the end-point (area under the curve 0.64, confidence interval 0.47–0.82).

Discussion

Our study shows that pre-operative forward SV is a significant determinant of worse perioperative course due to hemodynamic compromise. Echocardiography has reasonable accuracy for SV measurement when compared to termodilution [16, 17]. Cardiac output measurement by Doppler echocardiography has been validated in patients undergoing cardiovascular surgery [18]. Not all echocardiographic laboratories routinely perform such a measurement in patients with MR. Many echocardiographers and clinicians concentrate on LVEF, which is a very important parameter, but normal LVEF in MR patients with low LV afterload does not exclude significant LV dysfunction. In our study, SV was an independent predictor for perioperative hemodynamic status, and a more powerful one than LVEF. Thus, LV forward SV should be considered as an important parameter in MR patients referred for cardiac surgery.

Right ventricular dilatation was the second independent predictor. The cause of right heart dysfunction in patients with MR is chronically increased right ventricular afterload. Our data confirms previous findings. Shields et al. [19] found that impaired right ventricular ejection fraction was a common finding in patients with mitral regurgitation. Pre-operative RV dysfunction is a predictor for post-operative LVEF after mitral valve replacement, as it is also for late outcome after mitral valve repair in patients with severe heart failure [9, 10]. The right ventricle was enlarged in 60% of the patients and pre-operative RV dysfunction, defined as TAPSE < 22 mm, was observed in 66% of patients. On the other hand, RVSP is a strong, but imperfect, parameter for RV overload assessment in patients with right heart dysfunction [20]. In our group, elevated RVSP was present in only 43% of patients. We previously reported that pre-operative RV dilatation is a marker of poor survival in patients with MR and LV dysfunction [11]. In this study, we found that pre-operative RV enlargement is associated with perioperative hemodynamic compromise and increased duration of ICU stay. The cut-off value for RV end-diastolic volume in this study confirms our previous findings [11]. The results of the current study should encourage further investigation into both hemodynamic parameters and right heart function in patients with severe mitral regurgitation. In order to preserve group homogeneity, the study material consisted of patients with organic MR, unsuitable for mitral valve repair. Thus, the study conclusions may not be fully applicable to patients undergoing valve repair.

Limitations of the study

The limitations of this study are the relatively small sample of the cohort, and the single centre experience.

Conclusions

Right heart size and pre-operative stroke volume are significant predictors of the perioperative hemodynamic status in patients with mitral regurgitation undergoing mitral valve replacement.

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